office was called upon, editorially, for explanation of the phenomenon.

South to southwest of Buffalo is Lake Erie, while the Niagara River runs along the entire west side of the city. Lake Erie, for a distance of about two miles from the source of Niagara River, and the river itself, were free from ice. The temperature of the water in the river was 34° F. and the current had a velocity of about 8 miles per hour.

The conditions of the meteorological elements concerned in the phenomenon, as observed at the Weather Bureau station on the night in question, are shown in the following table:

	P. M., February 15.					A. M., February 16.									
	8.	9.	10.	11.	12.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Wind direction	w.	w.	se.	s.	s.	s.	sw.	sw.	sw.	sw.	sw.	sw.	sw.	sw.	sw.
Wind movement	2	2	1	3	1	3	3	2	3	3	3	3	4.	3	5
Air temperature	20	19	17	16	15	14	13	12	13	12	11	10	8	8	11
Relative humidity, per cent	73	...	...	...	...	...	...	...	...	...	...	...	91	...	...
Dew-point, degrees	13	...	...	...	...	...	...	...	...	...	...	...	6	...	...

Dry and wet bulb thermometer readings taken over the water would have been interesting, but it is clear from the data at hand that, since the water of both lake and river was 14° or more warmer than the air, heat radiating from the water warmed the quiet, superincumbent air and greatly increased its capacity for water vapor. At the same time evaporation from the water surface nearly saturated this quiet, warm air; convectional currents mixed it with the colder layers above, thereby cooling it below its dew-point and condensing much of its vapor into fog particles. After the air had been well saturated with aqueous vapor, the wind slowly carried it over the city, where still further cooling caused more condensation and produced denser fog. The steady and rather rapid fall in temperature from 20° at 8 p. m. to 8° at 8 a. m. materially aided the formation.

As far as can be learned, the fog at its greatest density extended a distance of about five miles east of the Niagara River, while in a condition of less density it doubtless extended considerably beyond that limit.

The frostwork on trees and other objects had a thickness of one-eighth inch or more and was quite evenly distributed over their entire surfaces. Ordinarily we find hoarfrost on but one side of objects, but in this case its deposit on all sides was evidently due to the very sluggish air movement.

Fogs like that of February 15–16 are very rare in this locality, owing to the usually rapid movement of the air, especially from the directions in which the lake and river lie.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

GENERAL SUMMARY FOR MARCH, 1902.

The level of water in the artesian well rose during the month from 33.80 to 34.05 feet above mean sea level. April 1, 1901, it stood at 34.30. The average daily mean sea level for the month was 9.85 feet on the scale, 10.00 representing the assumed annual mean.

Trade wind days, 23 (1 of north-northeast); normal, 18; average force of wind (during daylight), Beaufort scale, 3.0; cloudiness, tenths of sky, 6.0; normal, tenths of sky, 4.6.

Approximate percentages of district rainfall as compared with normal: Hilo, 420; Hamakua, 520; Kohala, 480; Waimea, 530; Kona, 300; Kau, 200; Puna, 700; Olaa, 300; Maui, 300 to 500; Oahu, 300; Kauai, 380.

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, average maximum, 73.7°; average minimum, 66.4°; Waimea, Hawaii, 2,730 elevation, 73.5° and 60.2°; Kohala, 521 elevation, 73.4° and 64.0°; Waiakea, Kula, Maui, 2,700 elevation, 74.2° and 57.3°; United States Magnetic Observatory, 81.7° and 64.6°; W. R. Castle, 60 feet elevation, highest, 79.5°; lowest, 62.5°; mean temperature, 70.4°.

Rainfall data.

Stations.	Elevation.	March, 1902.
HAWAII.	*Feet.*	*Inches.*
HILO, e. and ne.		
Waiakea	50	55.16
Hilo (town)	100	58.57
Kaumana	1,250	83.83
Pepeekeo	100	67.29
Hakalau	200	61.84
Honohina	300	90.85
Laupahoehoe	500	88.92
Ookala	400	94.35
HAMAKUA, ne.		
Kukaiau	250	62.76
Do	900	73.82
Do	1,520	93.39
Do	3,300	78.30
Do	5,000	27.01
Paauilo	750	....
Paauhau (Mill)	300	48.45
Paauhau (Greig)	1,150	....
Honokaa (Muir)	425	49.24
Honokaa (Rickard)	1,900	....
Kukuihaele	700	42.61
KOHALA, n.		
Awini Ranch	1,100	....
Niulii	200	27.43
Kohala (Mission)	521	26.09
Kohala (Sugar Co.)	235	21.05
Hawi Mill	600	28.20
Puuhue Ranch	1,847	30.51
Waimea, c.	2,720	27.34
KONA, w.		
Kailua	950	....
Holualoa	1,350	10.17
Kealakekua	1,580	10.17
Napoopoo	25	6.85
KAU, se.		
Kahuku Ranch	1,680	3.89
Waiohinu	1,000	10.59
Honuapo	15	9.52
Naalehu	650	10.31
Hilea	310	9.00
Pahala	850	....
Moaula	1,700	....
PUNA, e.		
Volcano House	4,000	22.21
Olaa	1,690	74.76
Olaa (17-mile)	221	....
Kapoho	110	64.32
Kalapana, se	8	....
MAUI.		
Waiopae Ranch, s	700	....
Kaupo (Mokulau), s	285	34.49
Kipahulu, s	300	43.89
Hamoa Plantation, se	60	24.28
Nahiku, ne	60	....
MAUI—*Continued.*	*Feet.*	*Inches.*
Nahiku (Pogue)	1,600	102.46
Nahiku	800	74.65
Haiku, n	700	28.19
Kula (Waiakoa)	2,700	14.37
Kula (Erehwon), n	4,500	25.64
Puuomalei, n	1,400	40.62
Paia, n	180	22.11
Haleakala Ranch, n	2,000	43.91
Wailuku, ne	200	12.43
OAHU.		
Punahou (W. B.), sw	47	11.67
Kulaokahua, sw	50	11.95
Makiki Reservoir	120	14.25
U. S. Naval Station, sw	6	11.64
Kapiolani Park, sw	10	7.84
Manoa (Woodlawn Dairy), c.	285	25.52
School street (Bishop), sw	50	11.31
Pacific Heights, sw	700	22.40
Insane Asylum, sw	30	13.61
Kamehameha School	75	18.01
Kalihi-Uka, sw	260	29.91
Nuuanu (W. W. Hall), sw	50	13.24
Nuuanu (Wyllie street), sw.	250	....
Nuuanu (Elec. Station), sw	405	21.21
Nuuanu (Luakaha), c	850	44.25
Waimanalo, ne	25	17.06
Maunawili, ne	300	15.31
Kaneohe, ne	100	....
Ahuimanu, ne	350	14.51
Kahuku, n	25	7.90
Waialua, n	20	6.26
Wahiawa, c	900	9.81
Ewa Plantation, s	60	7.68
Waipahu, s	200	9.53
Moanalua, sw	15	13.59
Magnetic Station	50	6.62
KAUAI.		
Lihue (Grove Farm), e	200	19.79
Lihue (Molokoa), e	300	19.45
Lihue (Kukaua), e	1,000	32.50
Kealia, e	15	24.35
Kilauea, ne	325	31.95
Hanalei, n	10	36.50
Waiawa, sw	32	8.15
Eleele, s	200	....
Wahiawa Mountain, s	2,100	....
McBryde (Residence)	850	29.20
Lawai	450	28.97
Delayed February reports.		
Ookala	......	9.29
Moaula	......	1.30
Kapoho	......	0.43

The principal features of the month were the heavy storms which characterized the first and last 10-day periods, with continuous fine weather in most parts during the middle of the month. A northeasterly storm set in on the 27th of February, and was recognized on Hawaii Island as a norther. At the foot of the north slopes of Mauna Kea, Mauna Loa, and Haleakala the rainfall was unparalled; at Kukaiau, Hamakua, Hawaii 1,600 elevation, 62 inches fell in four days, and 82 in eight days.

The storm which set in on the 18th was of similar character, but with less wind and with unusual electrical disturbance. At Luakaha, Nuuanu, 5 miles from the Honolulu post office, 5.55 inches fell in fifty minutes, on the 18th. The heaviest record for the calendar month was 102.46 inches at Nahiku, Maui, at 1,600 feet elevation, which may probably challenge the world's record. Ookala had 94.35 inches. Kukaiau as above 93.39 for the month, and 103 for 33 days, beginning February 27. Other heavy totals will be found in the table of rainfall.

These terrific downpours come with northerly winds following southerly airs which strike the abrupt northern slopes of the islands, so that there is combined the condensation due to the upward movement of the air, with that due to the sudden impact of a cold current upon a nearly stationary mass of warm, moist air surrounding a mountain. Neither of these causes in itself would produce such results, but combined they do bring on these so-called "cloud-bursts." From my observation on these islands, as well as in the States, I am inclined to think that meteorologists altogether undervalue the latter cause.

Snow fell on Mauna Kea, Mauna Loa, and Haleakala during these storms.

An earthquake was reported at Hilo March 30, 10:9 p. m. Heavy surf 1st to 7th; 15th to 24th.

Mr. Fleming, at the Magnetic Observatory, reports the mean dew-point, 62.6°; relative humidity, 73.4. Dr. Bond, Kohala, reports mean dew-point, 64.1°; mean relative humidity, 86.

OBSERVATIONS AT HONOLULU.

The station is at 21° 18′ N., 157° 50′ W.

Hawaiian standard time is 10^h 30^m slow of Greenwich time. Honolulu local mean time is 10^h 31^m slow of Greenwich.

Pressure is corrected for temperature and reduced to sea level, and the gravity correction, —0.06, has been applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force, or amounts of cloudiness, connected by a dash, indicate change from one to the other.

The rainfall for twenty-four hours is measured at 9 a. m. local, or 7.31 p. m., Greenwich time, on the respective dates.

The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet, and the barometer 50 feet above sea level.

Meteorological Observations at Honolulu, March, 1902.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 1:30 a. m. Honolulu time.									Total rainfall at 9 a. m., local time.
				Temperature.		Means.		Wind.		Average cloudiness.	Sea-level pressures.		
		Dry bulb.	Wet bulb.	Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.		Maximum.	Minimum.	
	*	†	†			‡	‡		§				
1	30.05	67	58.5	72	63	54.0	65	nne-sw.	6-2	4	30.09	29.99	0.01
2	30.06	68	60	73	65	54.5	60	ne.	6-7	5	30.12	30.03	0.04
3	30.06	68	62	74	66	56.7	64	ne.	5-6	4	30.14	30.05	0.24
4	30.02	70	63	74	65	58.5	67	ne.	6-7	6-10	30.10	29.98	0.80
5	29.99	69	61	71	65	59.3	72	ne.	5-7	10	30.10	29.98	1.60
6	29.97	68	66	73	66	59.3	72	ne.	5-7	8	30.02	29.93	0.90
7	30.05	68	64	73	67	64.3	86	ne.	4	9	30.07	29.96	0.70
8	30.04	68	62.5	72	67	61.3	75	ne.	4-5	4	30.09	30.01	0.02
9	30.01	63	62	74	67	60.3	72	ne.	4-0	6-10	30.07	30.00	0.02
10	30.01	63	62	78	62	62.5	77	ne.	0-4	3	30.05	29.96	0.00
11	30.00	63	62.3	79	62	63.5	81	ne-se.	0-2	3-0	30.06	29.95	0.00
12	30.00	65	63.7	78	63	64.7	85	se.	1-0	1-4	30.02	29.94	0.00
13	30.02	62	61.3	80	63	63.7	80	se-ne.	1	3-0	30.07	29.96	0.00
14	30.04	65	63	79	61	63.5	78	ne.	2	2	30.07	29.98	0.00
15	30.00	71	67	79	63	64.7	77	ne.	3-0	1	30.08	29.97	0.00
16	29.98	71	64	79	70	63.3	72	ne.	3	4	30.07	29.95	0.00
17	29.96	67	64	78	70	61.5	72	ne.	3	6-1	30.06	29.96	0.13
18	29.94	67	64.5	76	63	61.5	72	ne-e.	5-1	7-1	29.99	29.92	0.23
19	29.89	65	63	73	64	63.0	78	ne.	3	8-3	29.99	29.90	0.01
20	29.95	66	63.5	79	65	62.3	75	ne.	3-4	2	29.99	29.89	0.02
21	29.95	70	67.5	79	65	63.3	75	se-ne.	2	4	30.02	29.90	0.06
22	29.97	69	66	75	70	64.7	78	ne.	3-4	8	30.06	29.98	0.80
23	29.96	71	64	75	68	63.7	76	ne.	3-5	9	30.04	29.95	0.03
24	29.99	71	66.5	74	71	62.7	75	ne.	4	9	30.06	29.97	0.34
25	29.91	71	68.5	74	69	64.7	78	ne.	4-5	10	30.02	29.91	0.66
26	29.87	68	67	77	71	68.5	89	ne-se.	1-0	8-10	29.95	29.86	0.80
27	29.86	69	68.3	79	66	70.0	89	s.	1-2	4-10	29.93	29.85	0.48
28	29.90	70	69	73	68	68.5	95	se.	1	10	29.96	29.86	1.64
29	29.89	70	69.3	76	66	69.0	91	sw.	1-0	10	29.95	29.85	0.28
30	29.82	69	67.5	77	69	69.0	88	sw-ne.	1-0	10	29.95	29.82	0.06
31	29.79	64.7	64.3	77	67	66.5	88	s-n.	1-2	10	29.85	29.76	1.80
Sums	......	......	......	......	......	......	......	......	......	......	......	......	......
Means	29.966	67.6	64.2	75.9	66.5	63.4	78.2	....	3.0	6.0	30.033	29.935	11.67
Departure	—.041	......	......	......	......	+2.0	+5.0	....	......	+1.4	......	......	+7.96

Mean temperature for March, 1902, (6 + 2 + 9) ÷ 3 = 70.8; normal is 70.8. Mean pressure for March, 1902, (9 + 3) ÷ 2 = 29.976; normal is 30.017.

* This pressure is as recorded at 1 p. m., Greenwich time. † These temperatures are observed at 6 a. m., local, or 4.31 p. m., Greenwich time. ‡ These values are the means of (6 + 9 + 2 + 9) ÷ 4. § Beaufort scale.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

[For tables see page 156.]

Notes on the weather.—On the Pacific side the weather was fair and fine, excepting a few days with occasional showers at the beginning and toward the end of the month. In San Jose the air pressure was generally above normal up to the 15th and below normal after that date. The temperature was about normal, while the dryness of the atmosphere was remarkable. Although there were four days of rainfall (against two, mean number for thirteen years), the sunshine was nearly fifty hours in excess of the normal. On the Atlantic side there was little rain, and the weather was generally fine.

Notes on earthquakes.—March 18, 5^h 44^m p. m., slight shock, NW-SE, intensity III, duration 7 seconds.

FURTHER EXPLANATIONS.

By SIMON NEWCOMB, dated January 20, 1902.

Not until a few days ago was I aware that a paper asking certain critical questions about statements on meteorological subjects made by me in a popular article, had appeared in the MONTHLY WEATHER REVIEW for August, 1901. I shall take up the three points in question, seriatum.

The first concerns the cause of rain. I think it quite likely that I may be wrong in this point, and, therefore, shall not argue it, but merely remark that I have not yet seen any explanation of an all-day rain which seemed to me any more satisfactory than the old one which I mentioned.

The second point at issue is the cause of a thunderstorm. I attributed this to a rise of warm air and a fall of cold air to take its place. On this the Editor remarks: "The development of electricity by the rise of hot air and the descent of cold air is, we believe, a new thought in the physics of the atmosphere."

This remark seems to show that theoretical meteorology is either much less advanced or much more advanced than I had supposed. The above view was based purely on those casual observations which everyone may make in the course of his life. When, however, they are challenged, one hardly knows where to begin. I shall, therefore, confine myself to a statement of propositions, asking the Editor to point out where his dissent comes in:

(1) In spring and early summer it frequently happens that the excess of temperature of the air near the ground above that at a higher elevation is greater than the excess in a state of adiabatic equilibrium.

(2) The necessary result of this state of things is an instability of equilibrium. The colder air above at some point breaks through the stratum of warm air below and the latter rises up to take its place.

(3) The result is a colder wind blowing away from the place where the descent occurs and toward the place where the air is ascending. We thus have the familiar phenomenon at the commencement of a thundershower, when for a few minutes a heavy wind blows away from the seat of the storm.

(4) This state of things is nearly always accompanied by lightning, and the other phenomena of a thunderstorm.

(5) Lightning is produced by an electric disturbance and involves a generation of electric potential. Why or how the motion of the air should generate this potential, I must leave to others.

All I am stating are what appear to me the observed facts. If my propositions are wrong, I should like to have them corrected by a clear statement of the facts and causes of a thunderstorm.

The third point surprises me yet more, unless the Editor misapprehends my meaning when I speak of winds blowing in opposite directions. By this expression I meant merely opposite directions relative to the center of the advancing storm, or the center of disturbance. Different directions, would have been sufficient to say.

The Editor remarks: "The formation of a cyclone or whirlwind, as a consequence of winds blowing in opposite directions, is another theory long since abandoned. His omission of my phrase "near the place where the volume rises," I leave him to explain.